PROPOSAL

RADAR MAPPING SET

AN/APQ-56 ( )

AAN-40037-C

22 September 1955

Air Arm Division
Westinghouse Electric Corporation
Friendship International Airport
Baltimore, Maryland

TABLE OF CONTENTS

1. SCOPE

This proposal describes a high resolution, side-looking radar equipment and related items in response to request for quotation. The equipment and services to be supplied are:

Item 1 - One (1) Radar Mapping Set, AN/APQ-56 ( ) in accordance with Wright Air Development Exhibit WCLR-301 dated 7 March 1955 amended by this proposal. (Section 2 through 5).

Item 2 - One (1) Set Maintenance Tools and Test Equipment. (Section 6)

Item 3 - One (1) Set Spare Parts for Items 1 and 2. (Section 7).

Item 4 - Design and Fabricate necessary Components to retrofit the equipment supplied under items 1, 2, and 3 in accordance with Section 8 of this proposal.

Item 5 - Engineering Services to maintain and assist in field testing of the supplies delivered above at a base within the Continental limits of the United States for such period as required not to exceed 24 months after delivery of Item 1.

2. GENERAL INFORMATION

The proposed AN/APQ-56 ( ) equipment will consist of the following units:

1 - Dual 15 ft. linear array antenna

2 - Receiver-transmitters

1 - Power supply unit

1 - Recorder

1 - Pressurization system

1 - Set of interconnecting plugs and adapters

The Dual antenna will be similar in construction to the present AN/APQ-56 (XA-2) antenna but with a 15 foot aperture. The receiver-transmitters will be 100 KW units. The power supply and recorder will be of new design incorporating such features as separation of A-scope and control panel from the main recorder package, drift compensation, provisions for automatic data inputs, and continuous film motion. A dual pressurization system consistent with the 100 KW peak power output will be provided.

The equipment, defined by Exhibit WCLR-301 amended, is intended primarily for use in very high altitude aircraft. The proposed design is motivated by (a) this intended high-altitude application, (b) requirement for a relatively short delivery schedule, and (c) a desire to evolve an equipment which embodies the packaging, performance, and quality features described in WCLR-301 to the greatest extent consistent with (a) and (b).

Handbooks of maintenance and operating instructions will be supplied.

3. DETAILED DESCRIPTION

3.1 Antenna

Each equipment will require one Dual Antenna. Each Dual Antenna will consist of two end-fed linear arrays having a 15-foot by 5-inch aperture. It will be similar in mechanical construction to the 10-foot extruded antenna design for the AN/APQ-56 (XA-2) equipment and will have similar electrical performance except for a narrower horizontal beamwidth. One Dual Antenna assembly will provide two beams, each looking to one side of the aircraft.

The horizontal beamwidth at the one-way half-power level will be approximately 0.13°. This narrow beamwidth is considered necessary to provide adequate azimuth resolution at the maximum line-of-sight range of 18 miles. The mid-frequency skew (degrees off normal to antenna longitudinal axis) will be approximately 2°. All horizontal side lobes will be at least -12 db in power from the main lobe. This pattern will be generated by a plane-mounted waveguide containing a row of about 800 dipole-equivalent slots each properly phased and powered.

An ideal vertical pattern would be so shaped that equal signals would be received from identical area targets at any ground range from zero to maximum. The vertical pattern will be shaped to approximate the ideal within ± 1.5 db one way from an altitude of 70,000 feet over a ground range from 15 to 2 miles. A design goal will be to extend coverage to zero miles. The weight of each Dual Antenna assembly will be approximately 100 pounds.

3.2 Receiver-Transmitter

The receiver-transmitters will be 100 KW RT units as designed for AN/APQ-56 (XA-2), except the altitude limitation will be extended to 70,000 ft.

and an adapter box will be furnished to allow operation with the recorder, power supply and antennas described in this proposal. The equipment will be designed to operate in the temperature range of -55°C to +55°C.

Because the 100 KW magnetron size is relatively large, the receiver-transmitter will consist of two units which are referred to as the Receiver-Transmitter Unit and the Modulator Unit.

3.2.1 Modulator Unit

The pressurized modulator unit will contain the modulator, klystron, klystron high voltage supply, AFC control circuitry and the post amplifier. Both top and bottom of this unit will be removable to allow ready access to the components. Each modulator will weigh approximately 75 lbs. and occupy .75 cu.ft.

3.2.2 Receiver-Transmitter Unit

The receiver-transmitter unit will consist of two compartments, one pressurized and one unpressurized. The pressurized compartment will contain the magnetron cathode stem, the pulse transformer, magnetron filament transformer and a blower to cool the magnetron stem. The unpressurized compartment will contain the duplexer, preamplifier and AFC IF strip.

The power output of the magnetron will be approximately 100 KW peak, as determined by the magnetron rating. Power output of the equipment will be somewhat less than this due to losses in the duplexer and waveguide. In the APQ-56 (XA-2) RT unit these losses are about 1.4 db. It is expected that the losses in this unit will be comparable; this will be determined experimentally later in the program. Each receiver-transmitter unit will weigh approximately 75 lbs. and occupy 1.4 cu. ft.

3.2.3 Pressurizing System

RG-96/U waveguide will not handle the power generated by the 100 KW magnetron without pressurization. Present indications are that if air alone is used as a dielectric the pressures required will probably be great enough to damage the magnetron window. For this reason it will probably be necessary to use another gas such as sulfur hexafluoride in some portions of the equipment.

3.2.4 Adapter Box

It will be necessary to supply an additional unit which will contain relays and other minor components which were included in the APQ-56 (XA-2) power supply but which are not included in the power supply described in this proposal. The adaptor box will weight approximately 10 lbs. and occupy .25 cu.ft

3.3 Recorder

The recorder proposed herein will be a major redesign of the AN/APQ-56 (XA-2) unit although many circuits will be very similar to their present counterparts. The end product will have been designed with MIL specification requirements as design objectives, and to meet the specifications of WCLR-301 as amended by Section 5. The following paragraphs describe the proposed recorder. It will be noted that the sum of the improvements over the (XA-2) equipment will yield (a) a more flexible packaging configuration, and (b) a film record which is superior in ease of evaluation, precision, dynamic range, and total number of resolvable elements.

3.3.1 Packaging, General

The recorder will be built in four units, namely an automatic recorder, a monitor indicator, a set control panel, and an alignment control panel as indicated on the Sketch of Figure 1. Estimated volumes and weights are shown on the Sketch.

3.3.2 Automatic Recorder

The automatic recorder will contain the following subassemblies or functions: camera, magazine with film drive and film velocity control, two cathode-ray tubes, deflection yokes, regulated high-voltage power supply, regulated focus supply, photometer, dual video amplifier, drift integrator, range mark generator, altitude delay circuit, hyperbolic sweep generator, and deflection driver. Effective vibration isolation of this unit will be required.

3.3.2.1 Camera and Magazine

The optics section of the recording camera will be similar in function to the APQ-56(XA-2), containing two lenses, a reflecting mirror or prisms, and a viewing port to permit pre-flight alignment and focusing of the CRT trace. It will also contain a motor-driven exposure control to maintain constant exposure over the 250-1000 knot ground speed range.

The proposed recorder will use continuously moving 5-inch film to provide ground track scanning. There are several advantages of continuous film travel compared to the frame-by-frame technique which has been employed in the APQ-56(XA-2). For example, with continuous film travel:

(1) Interpretation, evaluation, and distance measurement

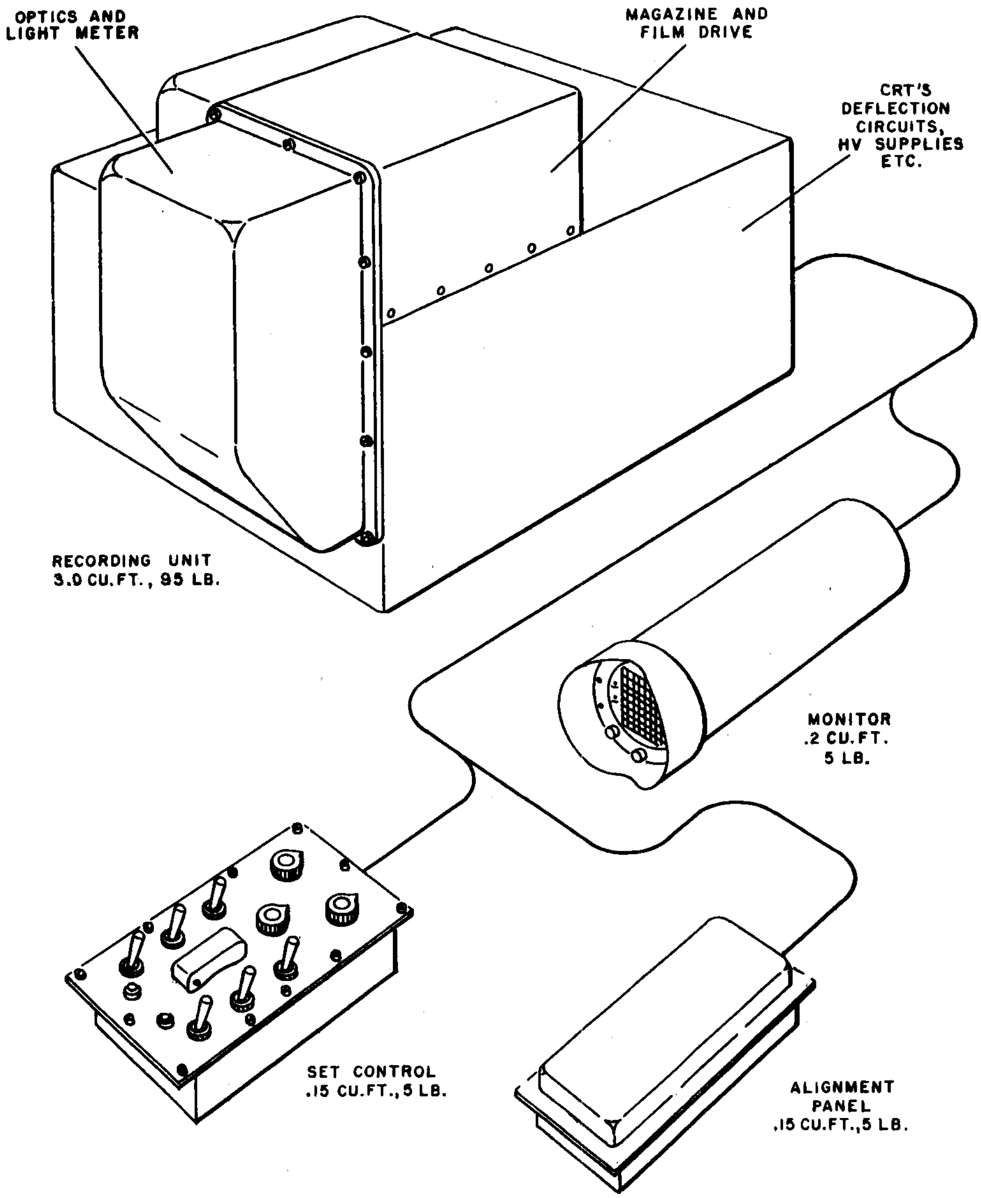

FIG. 1
PROPOSED PACKAGING FOR RECORDER

is considerably easier for photographic interpretation Personnel.

(2) Map precision is increased by elimination of a major component of distortion created by CRT scan.

(3) Range resolution in the recorder is improved since it is possible to use a longer trace on the CRT.

(4) It is very simple to compensate for the forward-looking skew angle of the antenna beams by merely mounting the CRT deflection yoke appropriately.

(5) Size, weight, and support complexity of mirrors and prisms in camera periscope may be reduced materially.

(6) Attainable image contrast is increased since the magazine aperture may be narrowed to a slit.

(7) The violent film transport transient does not occur.

Alternately, however,

(1) Extreme film transport smoothness is required. No camera has ever been produced which completely satisfies this requirement, and

(2) Only one line is excited on the face of the CRT which accelerates phosphor aging.

It is noted, however, that current USAF and British developments have come close to satisfying the transport requirements with virtual breadboard models. Westinghouse has discussed this problem with a number of reputable precision instrument manufacturers in the past months, and, on the basis of these discussions, considers that adequate smoothness can be obtained through good design and careful construction. This is supported by proposals received from reliable companies in this field to supply such a camera, built to the required tight specifications. The camera can be developed, constructed, tested and delivered in a time period compatible with the requirements of the proposed project. The second deterrent (above) is not serious since the CRT beam currents used in side-looking recorders are low, about one microampere average in the APQ-56 (XA-2).

A data chamber will be imaged on the edge of the film at 15-mile intervals of ground distance. Heading, time, a counter, and a data card will be recorded. (The counter visible to the operator will be advanced in synchronism with the data recording.)

The film transport speed mechanism will be built for control by either the remote manual ground speed control or by tie-in with a doppler system such as the APN-81 or APN-79.

A film emulsion such as Linagraph Survey will be used. The important desired characteristics include high resolution, moderate gamma (near unity), large linear density range, blue sensitivity and low speed.

The basic film record geometry will correspond approximately to Figure 2.

3.3.2.2 Cathode-Ray Tubes

Two high resolution cathode-ray tubes will be used, similar to the DuMont type K1393 PAXM. This tube has a nominal spot size of .003 inch and

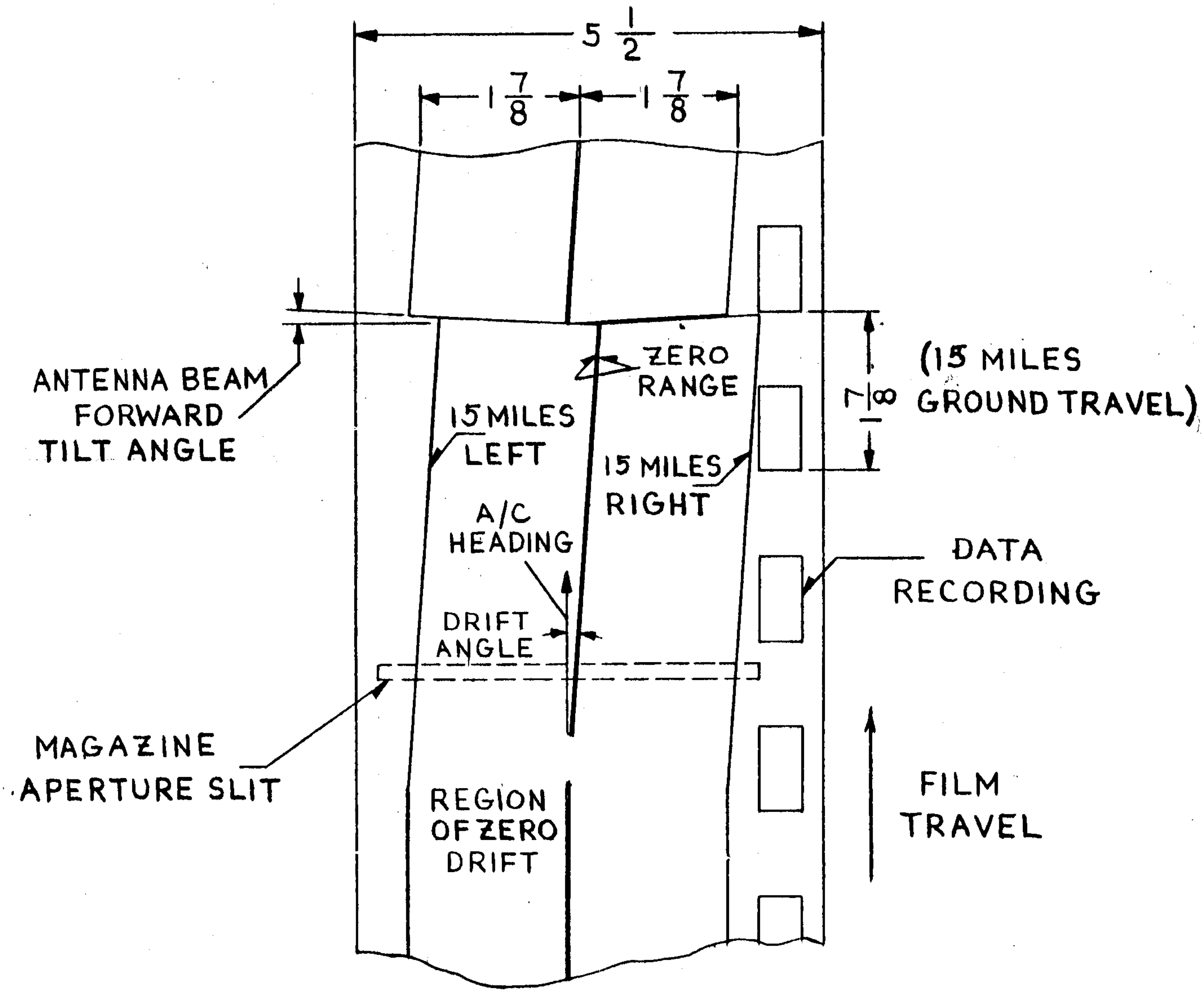

FIG. 2
FILM MAP GEOMETRY

a 4.25 inch useful face. To permit drift compensation the length of the ground range trace will be limited to about 3.25 inch yielding roughly 1000 line resolution, i.e. 90 ft. on a 15-mile range scale. It is likely that a faster phosphor than P11 will be used to permit monitoring of video light with a photocell. High-voltage connection to the tube will be designed for operation in ambient pressures at least as low as 5 psi, with 1.7 psi (50,000 ft. pressure altitude) as a design objective. The former limit has been surpassed in the (XA-2) and is adequate for most cockpit installations.

3.3.2.3 Signal Channel

The total receiver (the combination of i - f and video amplifiers) will be designed for a non-linear "compressed" transfer function as required for the best combination of small-signal sensitivity and large dynamic range. An approximate cube root characteristic seems more desirable than a logarithmic characteristic since such a shape would compensate for the cube-law CRT characteristic. This would result in the overall system unity gamma which the television industry has demonstrated to be very satisfactory for high-quality image reproduction. Development of circuitry to achieve such a response shape has been underway at Westinghouse for some time and is nearing completion.

The light meter problem is closely associated with the receiver-video combination. Receiver gain and CRT bias will be adjusted to produce predetermined light levels, as measured with a sensitive photocell, and will be maintained at these values by automatic control circuits. Such a procedure is required to maintain close system control essential for high-quality photographic results and to eliminate operator attention or interruption of the mapping process during flight.

3.3.2.4 Deflection System

A ground range hyperbolic sweep will be generated to cover 0-15 nautical miles (0-90,000 feet). Altitude will be set in over a range of 20,000 to 70,000 feet either manually at the set control panel or automatically through a synchro tie-in to an absolute altimeter. The altitude delay circuitry will be considerably redesigned from that used in the (XA-2) to provide delay accuracy comparable to the range mark accuracy. (See 3.3.2.6). The altitude range for this hyperbolic sweep will be coupled through stable deflection drivers to low-inductance CRT deflection yokes. "Striping" due to line voltage rapid fluctuations will be avoided by use of high-voltage supplies which incorporate built-in discharge tubes or other suitable instantaneous regulators.

3.3.2.5 Data Stabilization

Drift (or "crab") compensation will be provided to prevent map distortion resulting from departure of direction of travel from direction of heading. Ground speed and drift angle controls on the set control panel or tie-in to an APN-79 or APN-81 will provide output voltages proportional to velocity in the heading direction and velocity normal to heading. The former "ground track" velocity will be used to control film rate. The latter "drift" velocity will be integrated to generate a slowly increasing CRT deflection component such that the zero ground range line will gradually move away from its centered position, as indicated on Figure 2. When the total accumulated drift becomes so large that the image is at the limit of the useful film region, this integrator will be dumped automatically and the process repeated. With 20° maximum drift angle and the anticipated film record geometry this dumping typically will occur at greater than 15-mile increments.

Pitch and yaw compensation are not proposed for a number of reasons. First, in aircraft equipped with modern improved autopilots purported deviations from a constant flight altitude are held to less than ± 1 degree at rates less than ± 0.25 degree/sec. in all three axes, roll, pitch and yaw. With such limited magnitudes "smearing" (lost resolution) and distortion resulting from these deviations are negligible. Second, it is pertinent to note here that compensation of the display for much larger and/or more rapid pitch and yaw leads to unavoidable very severe striping of the picture. Experience has shown that striping is intolerable. The inevitable conclusion is that stable flight in the yaw and pitch axes is a "must" for effective side-look mapping and that pitch and yaw compensation in the recorder is neither necessary nor desirable.

3.3.2.6 Range Marks

One mile (6,000 feet) slant range marks will be provided with every fifth mark accentuated. The marks will be mixed with the video drive to the CRT's each time the data chamber in the camera is flashed, i. e., once each 15 miles of travel. The range mark accuracy will be better than ± 0.5 percent.

3.3.3. Monitor Indicator

The monitor indicator will be a time-shared A-scope presenting two parallel A-traces which display the respective video returns from the right and left antennas. A 3-inch CRT will be used. The video drive, range sweeps, and high-voltage will be derived from the automatic recorder unit so that a normal A-scope picture will indicate normal operation of the complete equipment. In addition, a counter either on the monitor panel or on the set control panel will be operated by the film travel so that it will advance one count for every 15 miles of ground travel.

3.3.4 Set Control

It is anticipated that the set control panel will contain the following operation controls: off-standby-on switch, altitude, ground speed, drift angle, manual-automatic data selectors.

3.3.5 Alignment Control

It is anticipated that the alignment control panel will contain the following controls: test meter, meter selector switch, CRT brightness, receiver gain, receiver tuning, manual-AFC, and pressurization. These controls will be accessible during flight to permit initial adjustment after equipment warm-up, and to facilitate simple checks by the pilot in case of suspected malfunction.

3.4 Power Supply

The power supply unit will contain the low voltage regulated d-c supplies and a portion of the system control and relaying circuitry. It will also serve as a system junction box.

It is anticipated that three regulated d-c sources will be provided capable of supplying the following voltages with the stated current capacities:

+ 300v	200 ma.

+ 150v	800 ma.
- 300v	200 ma.

An unregulated supply of 400v, 400 ma. will be provided. It is proposed that the power supply unit utilize in general the same circuitry which is employed in the AN/APQ-56 (XA-2) power supply. However, in order to effect a weight reduction, certain changes in the unit will be made and certain others will be considered and will be incorporated if found feasible. The transformers will be redesigned for smaller size and weight. The use of metallic rectifiers, probably silicon, will be considered. Metallic rectifiers offer the following advantages over gas diodes: less heat dissipation, no filament transformer required, no tube sockets and clamps required. Also, an overall reduction in the size of the rectifiers themselves can probably be realized. However, the application of silicon rectifiers to the proposed equipment will depend upon a further investigation of their environmental characteristics, life and general operating characteristics.

The system control circuitry will be similar to that used in the APQ-56 (XA-2). However, all relays associated entirely with the RT units including the overload and time delay relays will be removed from the power supply.

It is believed that by incorporating the changes outlined above the weight of the power supply can be reduced from the 45 pound weight of the APQ-56 (XA-2) power supply to 40 pounds.

4. ENVIRONMENTAL TESTS

The equipment will be tested in the aircraft environment and any malfunctions to the equipment caused by its operating environment will be corrected. It is anticipated that complete MIL environmental tests will be run by Westinghouse on equipment of this same design under an existing U.S.A.F. contract. Equipment supplied under this program will have the benefits of these environmental test results.

5. DEVIATIONS TO EXHIBIT WCLR-301

The following comprise the deviations or exceptions to Exhibit No. WCLR-301 dated 7 March 1955. The paragraph headings refer to paragraphs of the referenced exhibit.

Paragraph	Deviation or Exception
1.1.1	Change 50,000 feet to 70,000 feet.
3.3 through 3.3.21	The requirements of these sections affecting the design of the equipment shall apply as design objectives. Other sections are not applicable. Guaranteed compliance with specifications are not compatible with required delivery.
3.4	The Receiver-Transmitter will comprise more than 1 package. The smaller units are more adaptable to aircraft installation.
3.4.1	The weight per receiver-transmitter shall not exceed 150 pounds. Requirements for 100 KW power output necessitates weight increase.
3.4.3	Change 50,000 feet to 70,000 feet. Add "Dual pressurization system is mandatory for tactical operation."
3.4.5	Each transmitter section of the receiver-transmitter shall deliver peak RF power of approximately 100 KW commensurate with the magnetron ratings. Requirement of 100 KW minimum cannot be met with available magnetrons.

3.4.7 Delete.

.01 microsecond rise time is inconsistent with optimum system performance.

3.4.9 Pulse repetition frequency shall be the maximum consistent with magnetron peak power output and radar range requirements.

4 KC prf is incompatible with magnetron ratings.

3.4.12 An automatic gain control circuit shall be employed to stabilize the receiver gain during long periods of unattended operation.

Dynamic range requirements covered by 3.4.16 as amended herein.

3.4.13 The specified stability and temperature range shall apply as design objectives only.

State-of-the-art and required delivery do not permit guaranteed performance as specified.

3.4.16 In place of the lin-log video requirements substitute the following: "Receiver dynamic range. - A non-linear receiver characteristic shall be employed to provide an extended dynamic range for the complete receiver-recorder combination."

Lin-log characteristic is not optimum shape.

3.5 The monitor oscilloscope and control panel(s) will comprise separate packaging units.

Separate packaging is required for installation flexibility.

3.5.2 Change to read: "The video return shall be used to intensity modulate true ground range sweeps on high-resolution cathode-ray tubes. A recording camera shall be focused on the traces with the film moved smoothly at a rate proportional to a function of aircraft true ground velocity. A monitor of the A-scope type shall be included, and in addition a viewing port shall be provided in the recorder to permit visual inspection of the traces appearing on the display cathode-ray tubes."

A continuously moving film technique will be employed.

3.5.3.1 Change to "Film Velocity Control".

A continuously moving film technique will be employed.

3.5.3.1.1 Change from "sweep trace rates" to "film velocity."

A continuously moving film technique will be employed.

3.5.3.2 The counter shall indicate amount of film used.

A continuously moving film technique will be employed.

3.5.3.4 Change to read: "Recorder circuitry shall be so arranged that in-flight level setting controls may be adjusted without interruption of the mapping process."

It may not be necessary to adjust all of the specified parameters in flight.

3.5.3.5 Change 50,000 feet to 70,000 feet. Also change to permit interchange of a maximum of 3 plug-in units to obtain optimum display accuracy over the specified range of altitude.

Add "Provisions are required for automatic feeding delay from the output (Shaft rotation or electrical voltage) of an absolute altimeter."

Within one mission the requirement of wide altitude range is not consistent with antenna limitations and compromises performance of the recorder.

3.5.4 Delete spot size specification and substitute "The cathode-ray tube resolution shall be equivalent to a minimum of 1000 lines per diameter."

Specification of spot size alone is inadequate to insure a high-resolution display.

3.5.6 Change to read: "Stabilization of data in the recorder shall compensate for aircraft drift angle (crab) error to ± 20 degrees with an accuracy of ± 1 degree. Provisions shall also be included for automatically feeding drift information to the recorder from a doppler system radar and computer such as the AN/APN-81 or AN/APN-79. Constant heading tactics may be assumed in the design of the drift stabilization circuitry."

For reasons see detailed description of the recorder in the proposal.

3.5.6.1 Delete

For reasons see detailed description of the recorder in the proposal.

3.5.6.2 Delete

For reasons see detailed description of the recorder in the proposal.

3.5.6.3 Delete

No stabilization is to be provided.

3.5.8 The 100 lb. limit shall apply as a design objective only.

Delivery requirements would not permit redesign if limit should be exceeded.

3.5.9.3 Delete

A continuously moving film technique will be employed.

3.5.9.4 Change to read: "At even increments of film travel the following information shall be displayed in the data chamber." Delete Figure 1.

A continuously moving film technique will be employed.

3.5.9.4.3 Change the word "identical" to "similar".

A somewhat larger counter on the control panel may be desirable for ease of reading.

3.5.10 Change to read: "The recording camera shall produce two simultaneous side-by-side exposures with the image of a cathode-ray tube trace having a length of approximately 1-7/8 inches."

A continuously moving film technique will be employed, plus allowance for drift correction as indicated in the proposal.

3.5.11 Change to read: "Circuitry shall be included to provide a reference mark for each 6000 feet of slant range, with an accuracy of $\pm$ 0.5 percent. Every fifth mark shall be accentuated. The range marks shall be applied momentarily each time the data chamber is recorded."

The desirability of slant range marks has been established.

3.5.12 Delete the requirement for a calibrated light source.

Circuit and operating simplification will result if sufficient phototube stability can be achieved.

3.5.13 Delete

Not applicable in combination with other changes.

3.6 Dual antenna is to be used for coverage of left and right side of aircraft.

3.6.1 The 120 lb. limit shall apply as a design objective only.

Delivery requirement would not permit redesign if limit should be exceeded.

3.6.2 Change to read: "Each antenna shall consist of a dual 15 ft. linear array with slotted waveguide feeds and suitable lenses for beam shaping. Flanges and waveguide shall be compatible with the remainder of the system."

More compatible for system operation in high altitude aircraft.

3.6.3.2 Delete

Not compatible with state-of-the-art.

3.6.4 Delete reference to "ATO compartment of RB-47E type aircraft" and substitute "in an unpressurized compartment of a reconnaissance aircraft."

3.6.5 Delete

Part of dual antenna design.

3.6.6 Change 50,000 feet to 70,000 feet.

3.6.7 Delete

Not consistent with installation in high altitude aircraft with flight stability of better than $\pm 1^\circ$ and roll rates of $.25^\circ$/sec. max.

3.6.8 Change "90 degrees" to "88 degrees" and change "longitudinal axis of aircraft" to Longitudinal axis of antenna."

The design value will be 88 degrees which is the closest to perpendicular that the state-of-the-art permits.

3.6.9 Change 40,000 feet to 70,000 feet. Change second sentence to read "Amplitude deviations from the optimum curve shall not exceed 1.5 db measured one way."

3.6.10 Change to read: "The pattern of each antenna in the horizontal plane shall not be more than 0.13 degree in beam width at the half-power points. Minor lobes shall be at least 12 db down compared to the peak intensity of the overall radiation pattern."

The amended version is compatible with 15 ft. antenna design.

3.6.11 Delete reference to rotary joint.

No rotary joint required without roll stabilization.

3.6.12 This requirement shall apply as a design objective only.

Accurate gain measurements are presently impractical at this beam width.

3.7.2 Delete

No requirement for 400 cps regulation is foreseen.

3.8.1 Change 50,000 feet to 70,000 feet.

3.9 Delete

3.10 Delete

3.11 Delete

4. Delete

See Section 4 of this proposal.

6.3.1 Delete

See Paragraph 3.3 as amended.

6. MAINTENANCE TOOLS AND TEST EQUIPMENT

Maintenance tools and test equipment will be furnished for field maintenance of the AN/APQ-56 ( ) equipment proposed. A detailed list of the tools and test equipment to be supplied will be forwarded by 1 November 1955. A complete AN/APQ-56 ( ) equipment will be included for use as a bench test set.

7. SPARE PARTS

Spare parts for the AN/APQ-56 ( ) equipment and maintenance tools and test equipment will be supplied for two (2) years operation. A detailed list of spare parts to be supplied will be forwarded by 1 December 1955. A complete AN/APQ-56 ( ) equipment will be included in the spare parts.

8. PROPOSED RETROFIT PROGRAM

8.1 General Description

It is proposed to retrofit the system outlined in Section 3 after delivery to a single channel K_a band radar system.

The modified system proposed is considered the most suitable for installation in fighter type aircraft in that it requires a minimum of panel space and materially reduces the system weight and volume.

Design of the equipment will be such that a minimum amount of the pilot's attention will be required during flight. A minimum amount of adjustment procedure will be required since the control complement will be equivalent to that required for a single sided system. AFC and automatic level control of the recorder settings will contribute to the automaticity of the radar operation.

Only one Receiver-Transmitter and modulator will be required per system. The two sections of the dual antenna will be alternately connected to the receiver-transmitter by a suitable switching arrangement. A recorder of new design will be required to display the Receiver-Transmitter video output on a single cathode-ray tube. The traces will be separated optically to provide the two images corresponding to the left and right target areas and will be photographically recorded on a moving strip film. Minor changes will be required in the power supply and installation. A simplified block diagram of this system is shown in Figure 3.

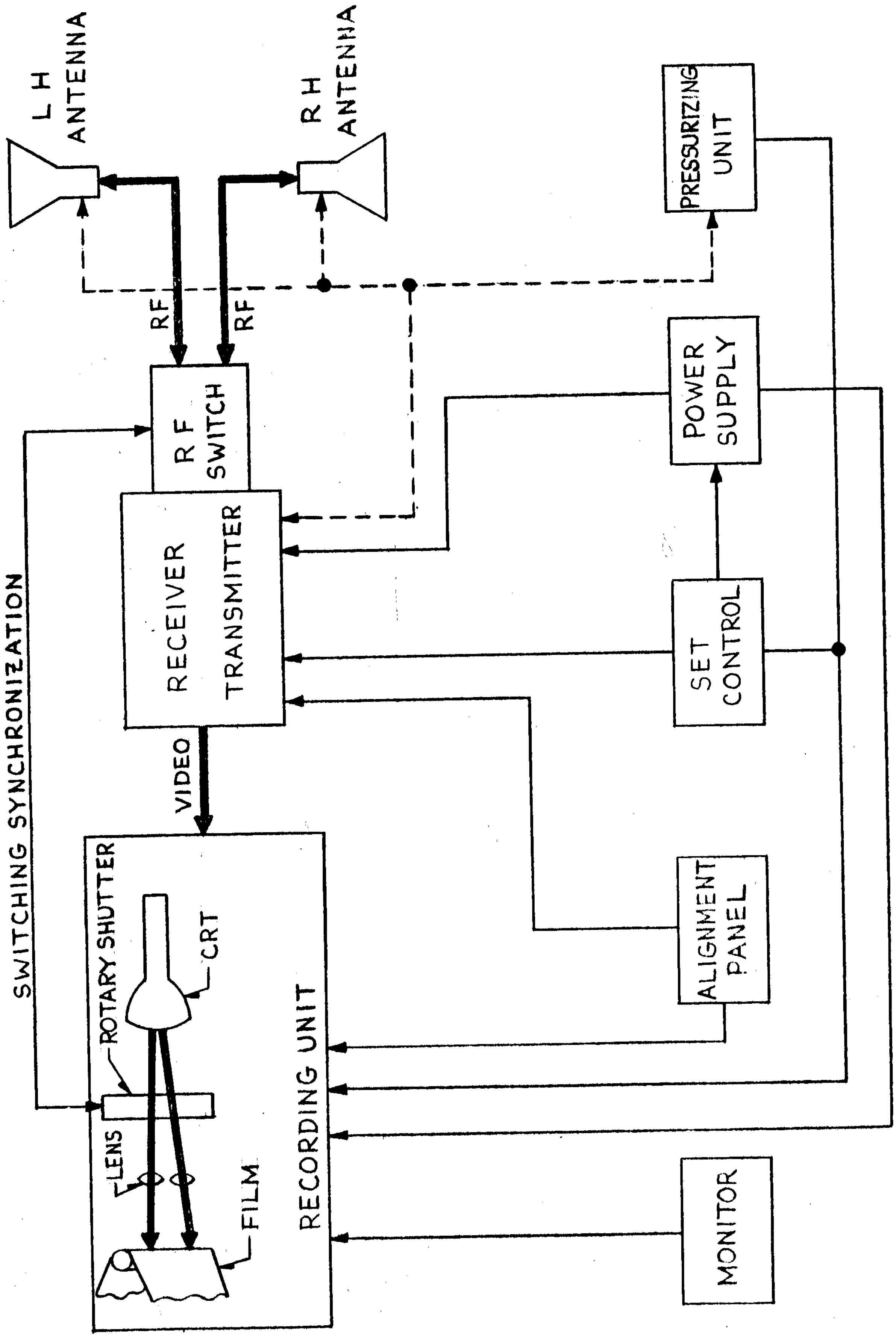

FIG. 3
OVERALL BLOCK DIAGRAM OF PROPOSED SYSTEM

FIGURE 3

8.2 Detailed Description

8.2.1 Receiver-Transmitter Unit

There are four basic methods of incorporating R/T units into a dual side looking radar system. These methods are as follows:

a) Two complete and independent R/T units may be used with each unit connected to its associated antenna. This method provides for the maximum magnetron power utilization, since the full power from two magnetrons is available.

   This method, however, is not considered to be the most suitable for a fighter reconnaissance aircraft because of the severe weight penalty of two R/T units and an added weight penalty in the power supply and recorder units.

b) Two magnetrons and two sets of receivers may be operated from a common modulator and power supply and packaged as a unit. This method is similar from a system viewpoint to that of (a) above and allows a small weight saving compared to two separate R/T units. This method still requires additional weight in the power supply and recorder units.

c) The transmitter power from one R/T unit may be divided to feed both sides of the system, and two receiving and recorder channels used with suitable directional coupler schemes to receive separated returns from the two sides. This system is somewhat lighter than the systems of (a) and (b) above, but is somewhat complex from a receiving standpoint, is inferior from a signal to noise ratio consideration compared with the other three possible methods, and does not allow a maximum weight reduction in the recorder and power supply.

d) The recommended method of incorporating an R/T unit into a Fighter Reconnaissance dual side looking system involves the use of one R/T unit, alternately switched from one antenna to the other.

This method is the lightest and most straightforward of all four systems, allows weight savings in the recorder design, since basically one recorder channel can be switched from side to side synchronously with the R/T. (See detailed description of Recorder Unit.)

The use of this method, as compared with two separate R/T Units, reduces system performance by something less than 3 DB and probably less than 2 DB. However, it appears that most of this system performance can be regained by the use of isolators and increased magnetron coupling described later in this section.

This small reduction of system performance, if magnetron power increases are not realizable, is not considered important in the application, and it is felt that the weight saving features of this method are very attractive for fighter type aircraft usage.

Figure 4 is a block diagram showing the proposed R/T unit.

The transmitter units will be modified to provide R-F switching, an isolator in the magnetron output and possibly a new AFC circuit.

The R-F switch will alternately feed the two sections of the dual antenna from one receiver-transmitter unit.

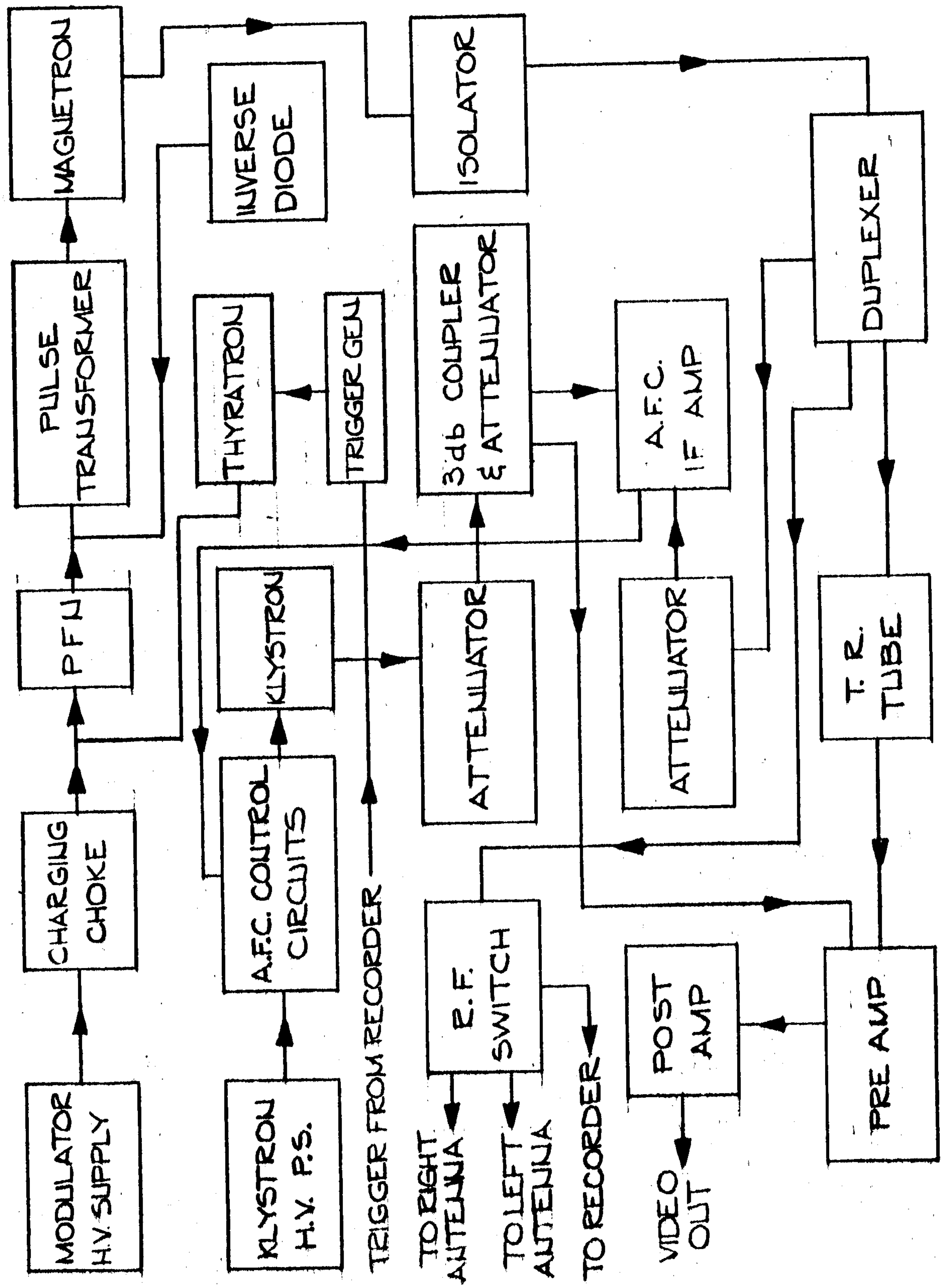

FIG. 4
BLOCK DIAGRAM OF PROPOSED RT UNIT

FIG 4

The isolator in the output of the magnetron will prevent changes in impedance caused by R-F switching and the antenna rotary joints, from affecting the magnetron and complicating the AFC problem. In addition, it may be possible to relax the pulling requirement on the magnetron which will permit the tube manufacturer to increase the coupling to the cavities and thereby increase the output power.

A new AFC circuit may be required to keep the klystron properly tuned. In a system containing a waveguide switch and rotary joints the AFC problem is relatively difficult since it must be able to compensate for rapid impedance changes in the R-F lines caused by switching. The isolator on the magnetron output will reduce the pulling (frequency shift) of the magnetron due to these impedance changes and make the AFC circuitry less critical.

8.2.2 Recorder Unit

8.2.2.1 General

The proposed recorder design is motivated by two factors, namely (a) maximum simplicity of operation as dictated by the requirement for installation in a fighter type aircraft and (b) maximum performance as required for successful automatic high-resolution mapping.

a) Simplicity

This recorder is to be used with a time-shared receiver-transmitter. Hence, at any instant, only a single-channel system will be required; i.e., one transmitter, one antenna, one receiver, one video amplifier, one display cathode-ray tube, one CRT deflection system, and one recording camera. During alternate time intervals signal energy will be switched from one antenna to another to permit mapping of the area on both sides of the aircraft. To record the received signals it will be necessary to switch from one film area to another film area in synchronism with the antenna switching. It will not be necessary to duplicate any of the components of a single-channel system ennumerated above except for antennas (2 required) and film areas (2 required) and provision for synchronous switching of these elements. Duplication of any of the other elements would be totally incompatable with the basic requirement for maximum simplicity, would increase weight, would decrease reliability, and would aggravate the alignment and performance monitoring problems.

In line with the foregoing basic philosophy, Westinghouse proposes a single-channel recorder with one essential exception - there will be a dual optical system to form two adjacent images of the CRT display with a shutter, operating in synchronism with the antenna switching, to produce alternate exposure of these two images. The result will be a recorder suitable for use with a two-side time-shared system but requiring only a single set of alignment and operating controls.

b) Performance

Experience has shown the absolute necessity for stable maximum performance if high-quality mapping is to be achieved. Insofar as the recorder is concerned, the most critical performance factors are resolution, distortion, and transfer characteristic (the relationship between film density and received signal strength). Resolution is limited primarily by the cathode-ray tube. It is important, therefore (1) to use the best possible CRT and (2) to use the longest possible trace consistent with tube dimensions. This latter consideration rules out such expedients as creating range sweeps right and left of a line through the center of the CRT screen for right and left mapping. The single CRT in the proposed recorder will utilize the full screen resolution capability for each side rather than divide this resolution between both sides.

Low-distortion mapping is achieved by use of ground range sweeps, compensation for antenna beam forward-looking angle, compensation for aircraft drift resulting from wind, and accurate use of ground speed information. All of these features will be included in the proposed recorder.

Proper design and control of the relationship between film density and received signal strength is as important in terms of information content of the final film record as any other single factor in an automatic side looking system. The factors which affect this transfer characteristic include output vs. input voltage characteristic of the receiver (i-f and video amplifiers), brightness vs. bias of the CRT, and film "gamma". Of equal importance are thevarious level settings such as CRT bias, receiver gain, video limit level, and camera aperture. Careful control of these design parameters and operating conditions will be a basic and important part of the proposed recorder.

8.2.2.2 Design

The recorder will be built in four units, namely an automatic recorder, a monitor indicator, a set control panel and an alignment control panel. Estimated weights and volumes are:

COMPONENT	ESTIMATED VOLUME	ESTIMATED WEIGHT
Automatic Recorder	2.50 Cu.ft.	75 lb.
Monitor Indicator	.20 Cu.ft.	5 lb.
Set Control Panel	.15 Cu.ft.	5 lb.
Alignment Control Panel	.15 Cu.ft.	5 lb.

The design and function of each unit will be basically the same as that of similar units described in Section 3 except as noted herein.

The Automatic Recording Unit will contain all of the actual recording components as indicated on the block diagram of Figure 5. The various components will be readily removable subassemblies in a common housing which, in turn, will be rigidly constructed and mounted on effective vibration isolaters to prevent loss of resolution as a result of aircraft vibration. The film magazine will be easily accessible for removal to facilitate ground handling. A viewing port, focusing magnifier, and ground glass reticle for aligning the images during pre-flight will be provided.

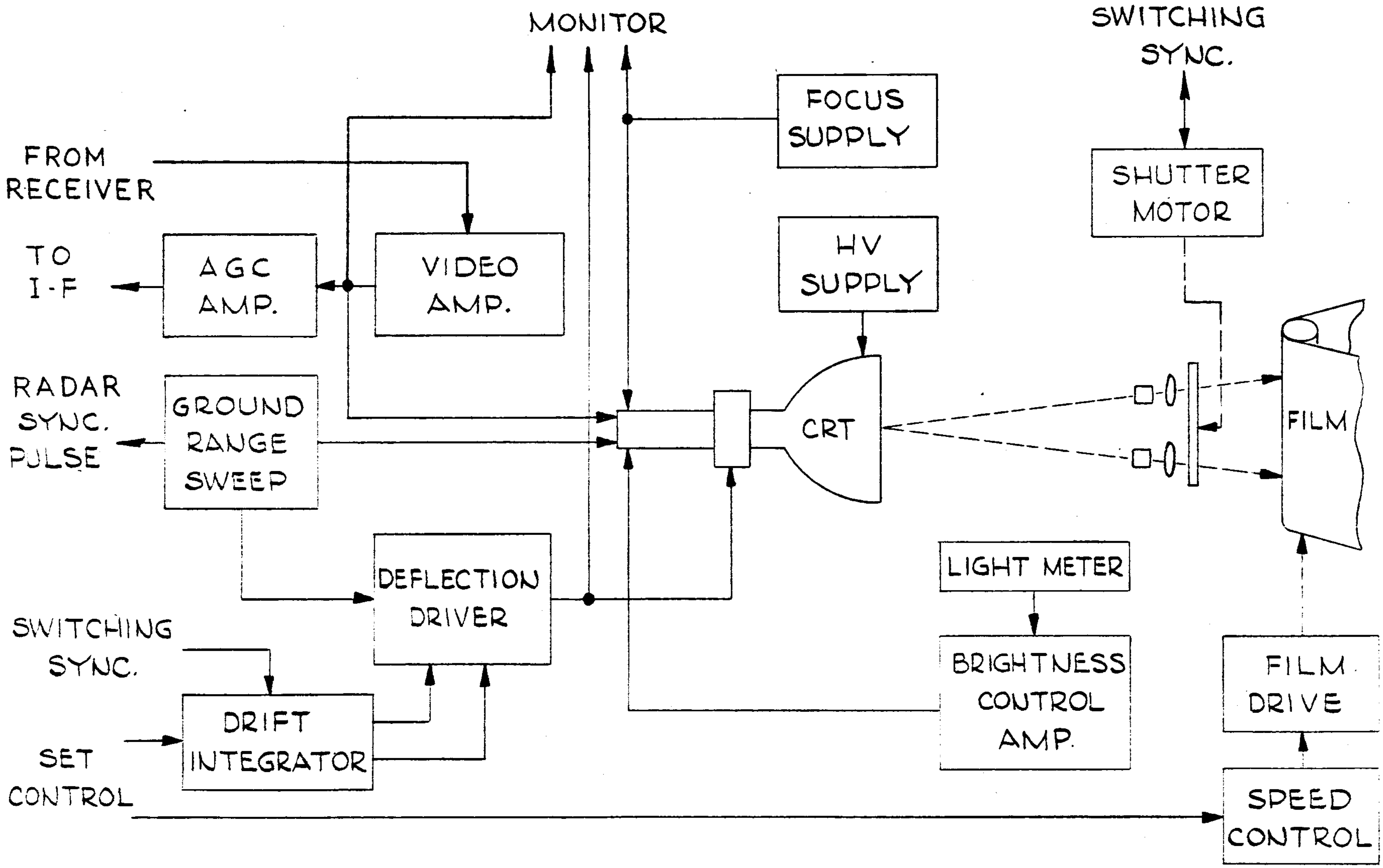

FIG. 5

FIG. 5
BLOCK DIAGRAM OF PROPOSED RECORDER

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The heart of the recorder is the CRT-camera combination. The proposed design conforms with the philosophy and general requirements outlined in paragraph 8.2.2.1 of this proposal. A single-high-resolution CRT will be used, such as a DuMont Type K-1393PAXM. This tube has a spot size of .003". To permit drift compensation the length of the ground range trace will be limited to about 3.25", yielding approximately 1000 line resolution, i.e. 90' on a 15 mile range scale. Except for drift compensation, the trace will be stationary on the CRT. Two images each approximately 2 inches long and reversed end-for-end with respect to each other will be formed from the 3.25 inch trace on the CRT. To conserve space, the optical path will be folded by means of prisms placed just before the two photographic lenses. Figure 6 shows the optics configuration. One lens will view the object trace through a normal silvered right-angle prism; this will yield a normal image on the film reversed from top to bottom. The second lens will view the same trace through an Amici 90 degree roof angle prism which is silvered on the roof angle only. The two prisms will be constructed to have equal optical path lengths; the lenses will have equal focal lengths. The image produced through the Amici prism will be reversed in both planes, while the other image will be reversed in one plane only. Thus the zero ground range ends of the image traces will be adjacent without necessitating end-for-end electronic switching of the CRT deflection.

A flicker shutter will be provided in the image space immediately behind the lenses. This shutter will be a disc with an equal number of open and closed sectors alternately dispersed around a line which passes through the centers of both optical paths. The turning rate and length of each

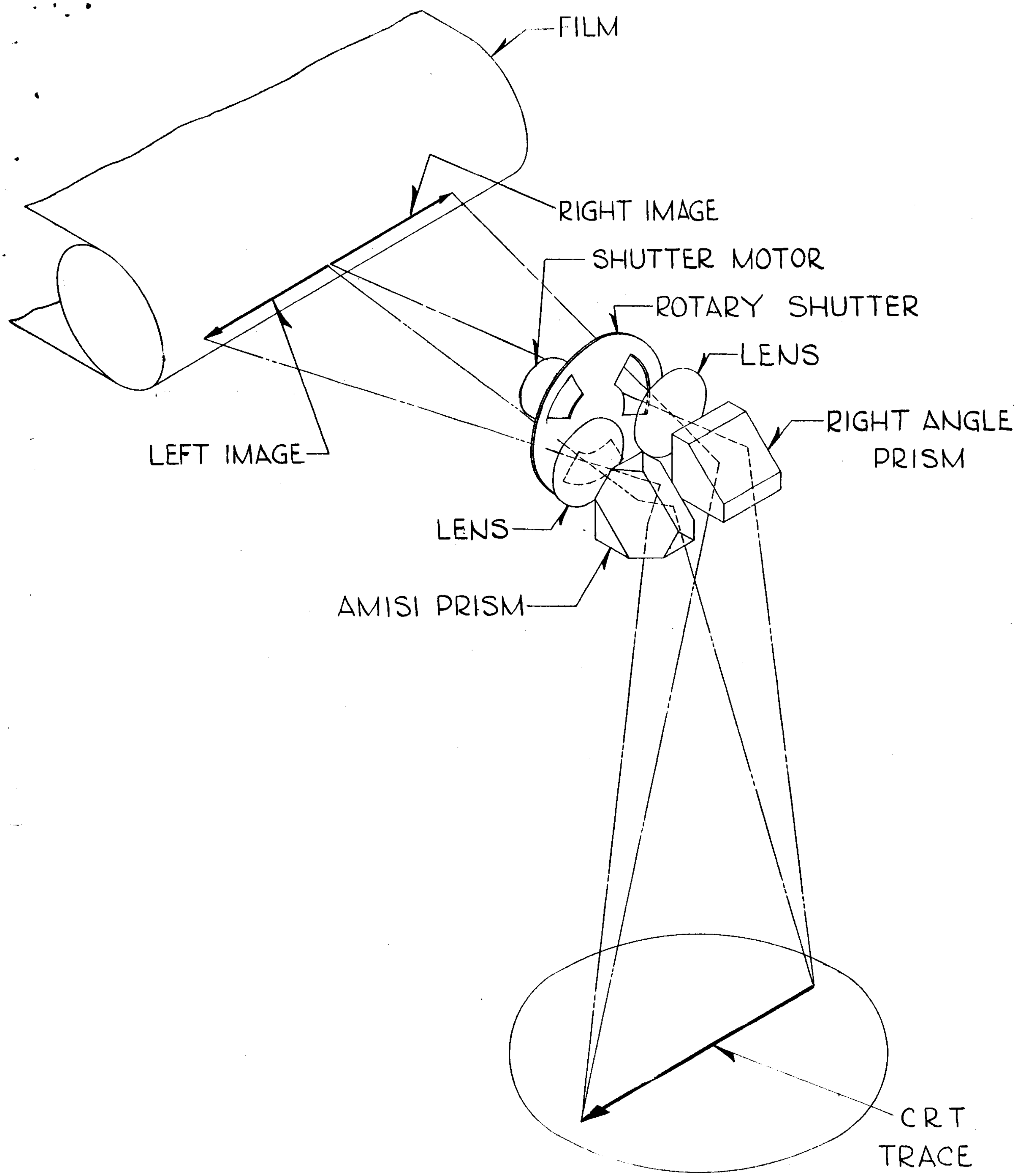

FIG. 6
CAMERA OPTICS

sector will be such that each individual optical path will be active for about 40% of the time at a recurrence rate in the neighborhood of 100 per second. (The requirement for this switching rate is derived as follows: at 1000 knots the aircraft travels 60 ft. or one resolveable element, in .036 sec. To prevent appreciable loss of resolution due to switching there should be at least 3 "looks" per resolveable element, i.e., .012 sec. maximum switching period.) The shutter will be driven by a synchro or other suitable device in synchronism with the antenna wave-guide switch. The CRT trace will be blanked during the switching transition interval.

The optics section of the camera also will contain a photo-cell for measurement and control of average CRT brightness, a motor-driven aperture control or equivalent to maintain constant exposure over the 250 to 1000 knot ground speed range, and a viewing port to permit pre-flight alignment and focusing of the CRT trace.

The proposed recorder will use continuously moving 5" film to provide ground track scanning similar to that supplied with the system described in Section 3.

The Set Control Panel, Monitor Indicator and Alignment Control will be similar to those described in Section 3. Modification of these designs will be required to accommodate the Single-Channel operation. Basic operating and monitoring procedures will remain the same.

9. ENGINEERING SERVICES

It is proposed to furnish necessary engineering services to perform maintenance of the supplies delivered and assistance for their field test at a base within the Continental limits of the United States for such period as required not to exceed 24 months after delivery of Item 1.